

## CLAIMS

1. A process for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state in a vehicle equipped with a run-flat tire system comprising run-flat tires and detection units each arranged in the respective tire and capable of measuring a given temperature of the tire, characterized in that when at least one run-flat tire among the run-flat tires is continuously run at the run-flat state by an abnormal lowering of an internal pressure accompanied with the occurrence of puncture or the like, the given temperature of the run-flat tire continuously running at the run-flat state is measured, and a residual lifetime of the run-flat tire is judged based on the measured given temperature.

2. A process for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 1, wherein the residual lifetime is judged on the basis of the rising degree of the measured given temperature.

3. A process for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 1, wherein the residual lifetime is judged by a runnable time and/or distance calculated on the basis of the measured given temperature until the trouble of the run-flat tire.

4. A process for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 1, 2 or 3, wherein the given temperature of the tire is an atmosphere temperature inside tire.

5. A process for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 4, wherein after the previous setting of a limit temperature being statistically the occurrence of the trouble when at least one run-flat tire among the run-flat tires is continuously run at the run-flat state by an extreme lowering of the internal pressure accompanied with the occurrence of puncture or the like, the atmosphere temperature inside tire is measured in the run-flat tire during the continuous running at the run-flat state, and a time predicted to reach to the limit temperature is calculated by using the measured values of the atmosphere temperature inside tire and data calculated from these measured values of the

atmosphere temperature inside tire, and the calculated running time and/or running distance are rendered into a runnable time and/or distance up to the occurrence of troubles in the run-flat tire.

6. A process for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 5, wherein after a relationship of an atmosphere temperature inside tire  $T$  to be measured with respect to a continuously running time  $t$  is previously determined as a function  $f(t)$  under various run-flat running conditions, when the run-flat tire is continuously run at the present run-flat running condition from a time point of measuring the atmosphere temperature inside tire, the running time and/or the running distance predicted to reach to the limit temperature are calculated by using the function  $f(t)$ .

7. A process for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 6, wherein the function  $f(t)$  is approximately expressed by  $f(t) = T_0 - A \exp(-Bt)$  (wherein  $T_0$  is a predicted saturation reaching temperature and  $A$  and  $B$  are coefficients), and when the run-flat tire is continuously run at the present run-flat running condition from a time point of measuring the atmosphere temperature inside tire, the running time and/or the running distance predicted to reach to the limit temperature are calculated by using the function  $f(t)$ .

8. A process for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 7, wherein the coefficient  $B$  is a constant value, and the coefficient  $A$  and the predicted saturation reaching temperature  $T_0$  are calculated from the measured temperature and a rate of temperature change thereof per unit time, and when the run-flat tire is continuously run at the present run-flat running condition from a time point of measuring the atmosphere temperature inside tire, the running time and/or the running distance predicted to reach to the limit temperature are calculated by using the function  $f(t)$  and substituting the calculated values therefor.

9. A process for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 8, wherein the function  $f(t)$  differs bordering a transition temperature which is a given

temperature lower than the limit temperature, and is approximately expressed by  $f(t) = T_0 - A \exp(-Bt)$  (wherein  $T_0$  is a predicted saturation reaching temperature and A and B are coefficients) when the atmosphere temperature inside tire is a temperature region lower than the transition temperature, and a case that the predicted saturation reaching temperature  $T_0$  is lower than the transition temperature is judged as a safety mode capable of continuously running at the run-flat state over a long time, and a case that the predicted saturation reaching temperature  $T_0$  is higher than the transition temperature is judged as a danger mode of predicting the occurrence of trouble during continuous running at the run-flat state, and when the run-flat tire is continuously run at the present run-flat running condition from a time point of measuring the atmosphere temperature inside tire, the running time and/or the running distance predicted to reach to the limit temperature are calculated by using the function  $f(t)$ .

10. A process for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 9, wherein the function  $f(t)$  is approximately expressed by  $f(t) = T_1 + Ct$  (wherein  $T_1$  is a measured temperature and C is a change ratio of temperature measured per unit time), and when the run-flat tire is continuously run at the present run-flat running condition from a time point of measuring the atmosphere temperature inside tire, the running time and/or the running distance predicted to reach to the limit temperature are calculated by using the function  $f(t)$ .

11. A process for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state according to any one of claims 1 to 10, wherein the run-flat tire is a so-called side-reinforced run-flat tire in which a reinforcing rubber is arranged on at least a sidewall portion of the tire at an inner surface side thereof.

12. A record medium recording a program for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state, in which the program is recorded to conduct the process according to any one of claims 1 to 11 with a computer.

13. An apparatus for judging a residual lifetime of a run-flat tire during continuous running at a run-flat state by conducting the process

according to any one of claims 4 to 11, which comprises detection units arranged in the respective run-flat tires and capable of measuring at least an atmosphere temperature inside tire in these tires, calculation means for at least calculating a running time and/or a running distance predicted to reach to the limit temperature from the measured value of the atmosphere temperature inside tire when the run-flat tire is continuously run at the present run-flat running condition, and memory means for at least memorizing basic data to be compared with data calculated by the calculation means.

14. A process for judging an end stage of a residual lifetime of a run-flat tire during continuous running at a run-flat state in a vehicle equipped with a run-flat tire system comprising run-flat tires and detection units each arranged in the respective tire and capable of measuring at least an atmosphere temperature inside tire, characterized in that when at least one run-flat tire among the run-flat tires is continuously run at the run-flat state by an abnormal lowering of an internal pressure accompanied with the occurrence of puncture or the like, the atmosphere temperature inside tire in the run-flat tire continuously running at the run-flat state is measured, and a ratio of temperature change at each measuring time is calculated, and a time point in which the calculated ratio of temperature change becomes higher than the ratio of temperature change calculated just before the calculation is judged as an end stage of the residual lifetime in the run-flat tire during continuous running at the run-flat state (Fourth Invention).

15. A process for judging an end stage of a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 14, wherein after a limit temperature being statistically the occurrence of trouble is previously set as a condition for judging the end stage of the residual lifetime of the run-flat tire, it is added that the atmosphere temperature inside tire in the run-flat tire reaches in the vicinity of the limit temperature.

16. A process for judging an end stage of a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 14 or 15, wherein as a condition for judging the end stage of the residual lifetime of the run-flat tire continuously running at the run-flat state, when the atmosphere temperature inside tire  $T$  to be measured is expressed by a function  $f(t)$

drawing a curve increased with a running continuous time  $t$ , it is added that a value of a second derivative  $f(t)''$  of the function  $f(t)$  is a positive value.

17. A process for judging an end stage of a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 14, 15 or 16, wherein the run-flat tire is a so-called side-reinforced run-flat tire in which a reinforcing rubber is arranged on at least a sidewall portion of the tire at an inner surface side thereof.

18. A record medium recording a program for judging an end stage of a residual lifetime of a run-flat tire during continuous running at a run-flat state, in which the program is recorded to conduct the process according to any one of claims 14 to 17 with a computer.

19. An apparatus for judging an end stage of a residual lifetime of a run-flat tire during continuous running at a run-flat state by conducting the process according to any one of claims 14 to 17, which comprises detection units each arranged in the respective tire and capable of measuring at least an atmosphere temperature inside tire, calculation means for at least calculating a ratio of temperature change from the measured value of the atmosphere temperature inside tire, and memory means for at least memorizing basic data to be compared with data calculated by the calculation means (Sixth Invention).

20. An apparatus for judging an end stage of a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 19, wherein the calculation means further calculates a value of the second derivative  $f(t)''$  in addition to the ratio of temperature change.

21. An apparatus for judging an end stage of a residual lifetime of a run-flat tire during continuous running at a run-flat state according to claim 19 or 20, wherein the basic data memorized with the memory means is values of the already calculated ratio of temperature change and the second derivative  $f(t)''$  and/or the limit temperature.